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(54) **ALIEN CROSSTALK SUPPRESSION WITH ENHANCED PATCH CORD**

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(21) Appl. No.: **13/539,947**

(22) Filed: **Jul. 2, 2012**

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Related U.S. Application Data

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(60) Provisional application No. 60/565,464, filed on Apr. 26, 2004, provisional application No. 60/488,566, filed on Jul. 18, 2003, provisional application No. 60/486,683, filed on Jul. 11, 2003.

(51) **Int. Cl.**
H01B 11/04 (2006.01)
H04B 3/32 (2006.01)
H01B 11/06 (2006.01)

(52) **U.S. Cl.**
CPC ***H04B 3/32*** (2013.01); ***H01B 11/06*** (2013.01); *Y10T 29/49117* (2015.01)

(58) **Field of Classification Search**
CPC H01B 11/04; H01B 11/06
USPC .... 174/27, 113 R
See application file for complete search history.

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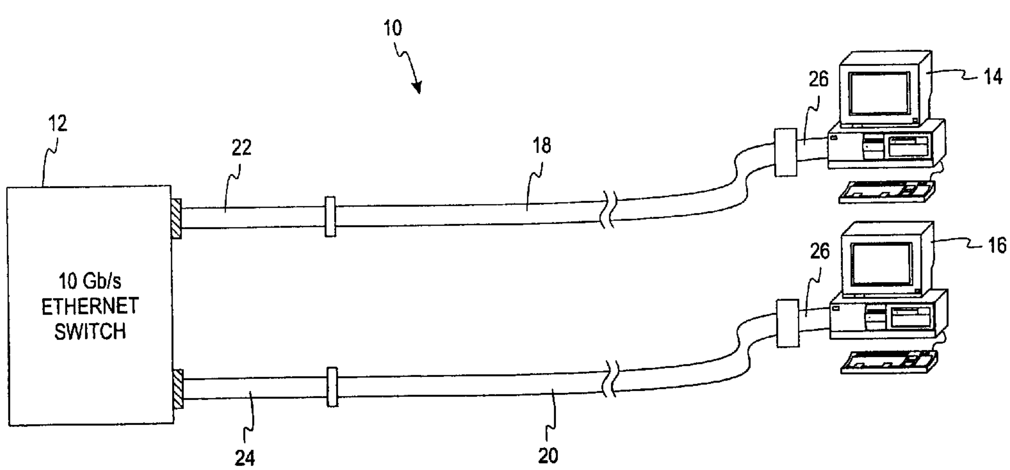
(74) *Attorney, Agent, or Firm* — Christopher S. Clancy; Christopher K. Marlow

(57) **ABSTRACT**

Systems and methods for decreasing alien crosstalk use enhanced patch cords for introducing additional attenuation. The enhanced patch cords are preferably shielded to reduce alien crosstalk down their lengths and also attenuate signals passing therethrough to a greater extent than standard communication patch cords. The interaction of two enhanced patch cords results in two suppression steps for alien crosstalk and only one suppression step for intended signal passing through a communication cable.

16 Claims, 6 Drawing Sheets



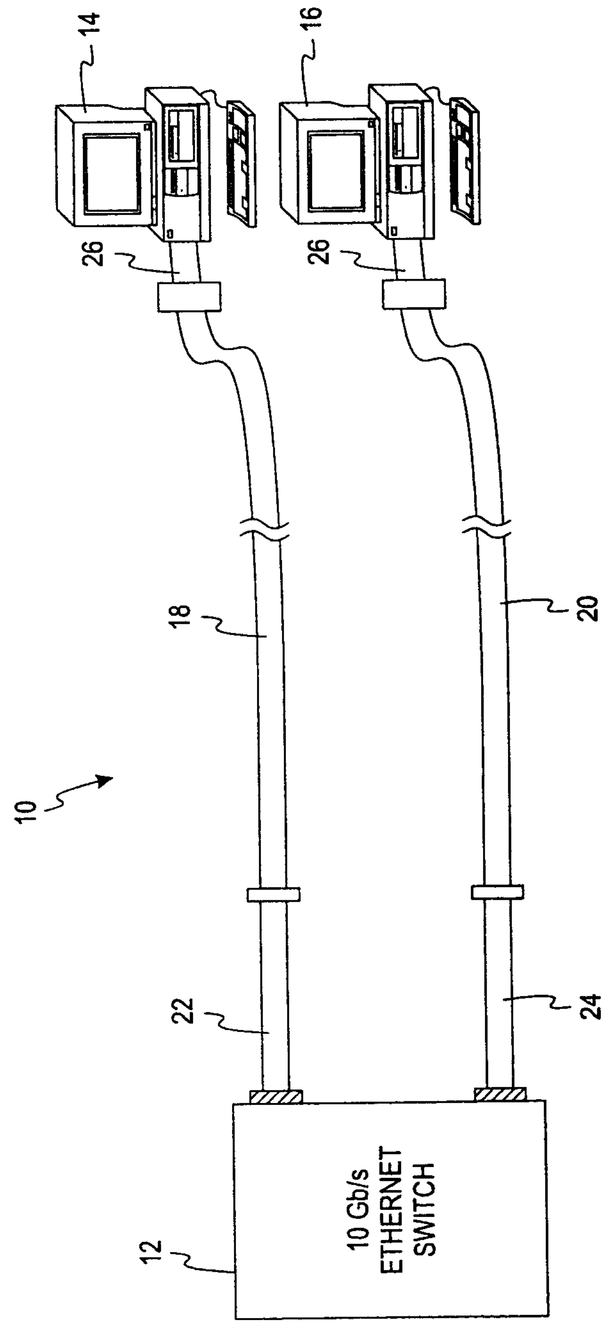


Fig. 1

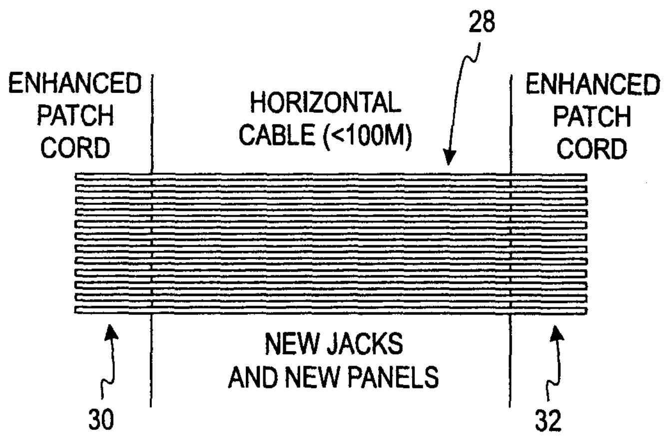

28
ENHANCED
PATCH
CORD
HORIZONTAL
CABLE (<100M)
ENHANCED
PATCH
CORD
NEW JACKS
AND NEW PANELS
30
32

Fig. 2

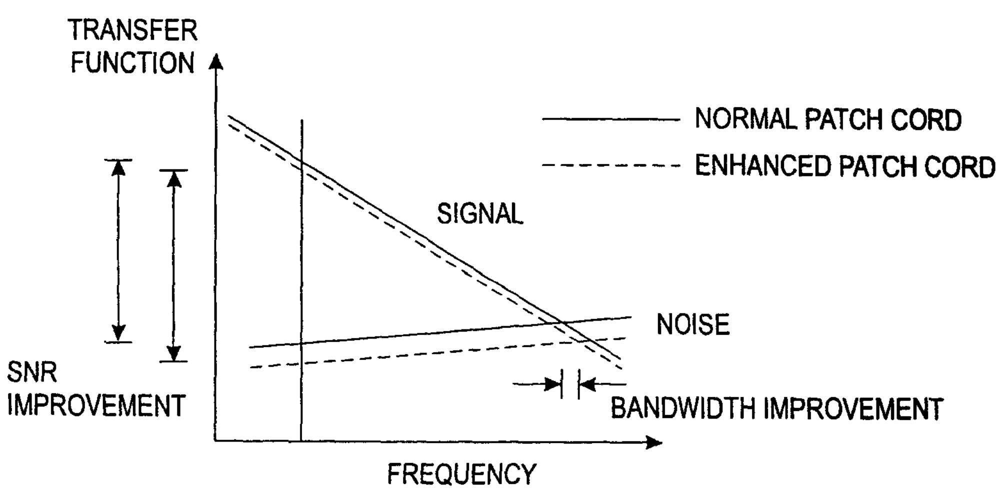

TRANSFER
FUNCTION
NORMAL PATCH CORD
ENHANCED PATCH CORD
SIGNAL
NOISE
SNR
IMPROVEMENT
BANDWIDTH IMPROVEMENT
FREQUENCY

Fig. 3

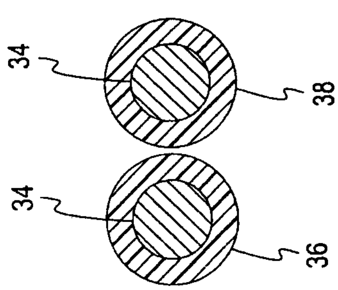


Fig. 4

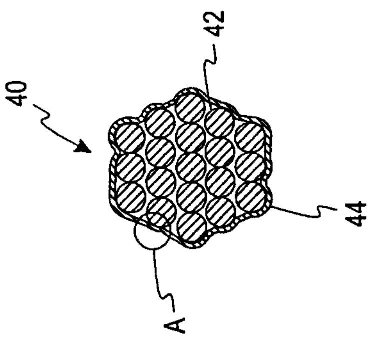


Fig. 5

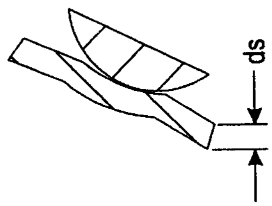


Fig. 6

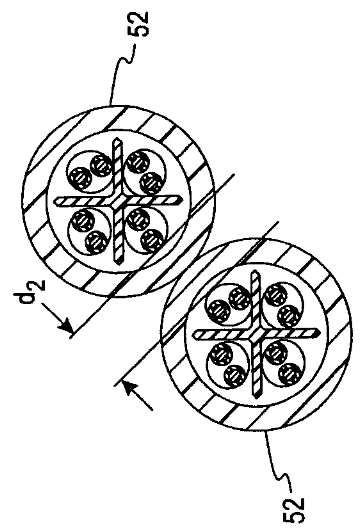


Fig. 7b

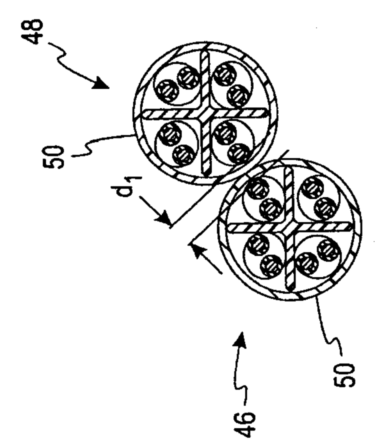


Fig. 7a

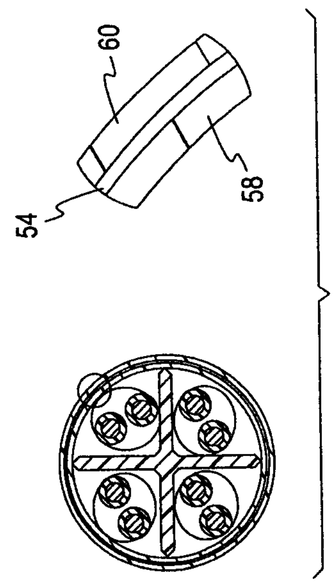


Fig. 9

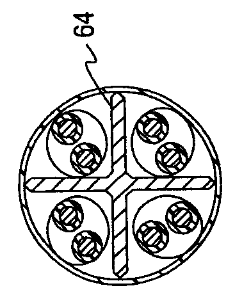


Fig. 11

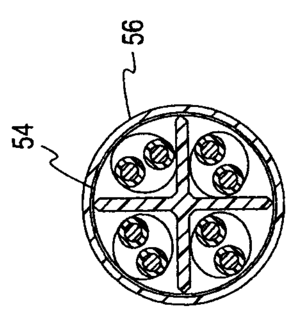


Fig. 8

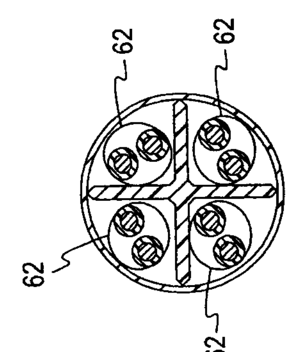


Fig. 10

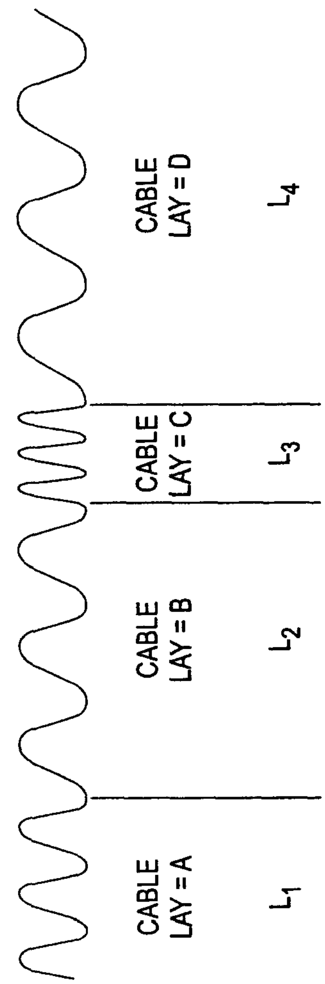


Fig. 12

ALIEN CROSSTALK SUPPRESSION WITH ENHANCED PATCH CORD

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 12/788,891, filed May 27, 2010, which is a continuation of U.S. patent application Ser. No. 11/468,848, filed Aug. 31, 2006, which issued as U.S. Pat. No. 7,728,228 on Jun. 1, 2010; which is a continuation of U.S. patent application Ser. No. 10/887,718 filed Jul. 9, 2004, which issued as U.S. Pat. No. 7,109,424 on Sep. 19, 2006, which claims the benefit of U.S. Provisional Patent Application Ser. No. 60/486,683, entitled "Alien Crosstalk Suppression with Enhanced Patch Cord Design," filed on Jul. 11, 2003; U.S. Provisional Patent Application Ser. No. 60/488,566, entitled "Alien Crosstalk Suppression With Enhanced Patch Cord," filed on Jul. 18, 2003; and U.S. Provisional Patent Application Ser. No. 60/565,464, entitled "Alien Crosstalk Suppression with Enhanced Patch Cord," filed on Apr. 26, 2004. These provisional applications are further incorporated herein in their entireties.

FIELD OF THE INVENTION

The present invention relates generally to communications systems and more specifically relates to systems and methods for suppressing alien crosstalk in communications.

BACKGROUND OF THE INVENTION

Suppression of crosstalk in communication systems is an increasingly important practice for improving systems' reliability and the quality of communication. As the bandwidth of a communication systems increases, so does the importance of reducing or eliminating signal crosstalk.

In wired communication systems, crosstalk is caused by electromagnetic interference within a communication cable or between multiple cables. Crosstalk resulting from interaction between cables is known as alien crosstalk.

While crosstalk resulting from signals running within a single cable interfering with signals within the same cable can be managed using electronic crosstalk reduction methods, alien crosstalk poses additional problems because the qualities of the interfering or disturbing signal(s) are not known. Alien crosstalk has proven problematic in implementations such as 10 Gbps Ethernet communication over an installed base of Cat 6 or Cat 5e cable. In such cables, alien crosstalk can significantly hamper communication performance. Specially-designed cabling could be used to decrease alien crosstalk, but replacing existing cabling with newly-designed cabling entails significant expense.

Thus, there exists a need for alien crosstalk suppression methods and systems that may be used with installed cable.

SUMMARY OF THE INVENTION

According to one embodiment of the present invention, an improved patch cord having increased attenuation improves performance of an installed cabling system.

According to another embodiment of the present invention, alien crosstalk between communication cables is decreased by a method of using attenuating patch cables connected to the communication cables.

According to another embodiment of the present invention, cabling systems employ an improved patch cord to decrease alien crosstalk between communication cables.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a plan view of a communication system according to one embodiment of the present invention;

FIG. **2** is a schematic view of a cabling installation with improved patch cords for providing alien crosstalk suppression;

FIG. **3** is a graph showing the increased signal-to-noise ratio in a communication system using an enhanced patch cord according to the present invention;

FIG. **4** is a cross-sectional view showing a conductor and lossy conductor insulation according to one embodiment of the present invention;

FIG. **5** is a cross-sectional view of stranded wires having a lossy conductive coating;

FIG. **6** is a detail view of the detail "A" of FIG. **5**;

FIGS. **7***a* and **7***b* are cross-sectional views showing the comparison of two cable pairs, with the cable pair of FIG. **7***b* having increased distance between crosstalk pairs;

FIG. **8** is a cross-sectional view of a cable having a surrounding shield;

FIG. **9** is a cross-sectional view of a cable having a modified surrounding shield;

FIG. **10** is a cross-sectional view of a cable having shielding surrounding each wire pair;

FIG. **11** is a cross-sectional view of a cable having a conductive spline;

FIG. **12** is a diagram illustrating varying cable lays along the length of a cable.

DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

Turning now to FIG. **1**, a communication system **10** is shown. In the communication system **10**, a network device such as the 10 Gb/s Ethernet switch **12** is connected to a plurality of devices, such as personal computers ("PCs") **14** and **16** by first and second communication cables **18** and **20**, respectively. It is to be understood that while FIG. **1** shows the communication cables **18** and **20** extending from a single network device to two devices, systems and methods according to the present invention will allow for the suppression of alien crosstalk between communication cables regardless of the types of devices to which the cables are connected.

Generally, alien crosstalk resulting from the interaction between the communication cables **18** and **20** will be coupled along the entire lengths of the cables **18** and **20**. The cables **18** and **20** act to suppress signal travelling through them to some degree, such that alien crosstalk occurring between the cables closer to the Ethernet switch **12** will be attenuated somewhat at the PCs **14** and **16**.

Crosstalk suppression is enhanced in the system of FIG. **1** by the use of first and second enhanced patch cords **22** and **24**. The enhanced patch cords **22** and **24** are designed to suppress crosstalk along their lengths, for example by providing additional shielding. In addition, the enhanced patch cords **22** and **24** attenuate communications signals and noise, such as crosstalk, travelling through them. Attenuation in the patch cords **22** and **24** may be accomplished in a number of ways. For example, attenuation may be increased by the use of finer-gauge wire within the enhanced patch cords **22** and **24** or by increasing the number of twists per inch in wires contained within the patch cords **22** and **24**.

The strength of alien crosstalk is dependent upon the strength of the interfering or disturbing signal. Thus, increased attenuation provided by the first enhanced patch cord **22** will reduce the signal level in the first communication cable **18**. As a result, the alien crosstalk coupled into the second communication cable **20** from the first communication cable will be reduced due to attenuation by the first enhanced patch cord **22**. Because the alien crosstalk caused by the first communication cable **18** in the second communication cable **20** will travel in both directions in the second communication cable **20**, the alien crosstalk will also be subjected to suppression in the second enhanced patch cord **24**.

For example, if a signal leaves the Ethernet switch **12** having a signal strength of 1 volt peak-to-peak, and the first enhanced patch cord **22** attenuates to 10% of the initial strength, the signal going from the Ethernet switch **12** to the first PC **14** will have a signal strength of 0.1 volt peak-to-peak. If 10% of that signal couples as alien crosstalk to the second communication cable **20**, the alien crosstalk in the second cable will have a signal strength of 0.01 volt peak-to-peak. If the second enhanced patch cord **24** also has attenuating properties that reduce signals to 10% of the initial strength, the alien crosstalk will be suppressed in the second communication cable **20** to 0.001 volt peak-to-peak. Thus, the alien crosstalk has been subjected to the effects of two enhanced patch cords **22** and **24**, and the signal from the Ethernet switch **12** through the second communication cable **20** has been subjected only to the effects of the second enhanced patch cord **24**. Optional enhanced patch cords **26** have been shown for connection to the PCs **14** and **16** and similarly operate to reduce alien crosstalk at the user side of the communication connection.

Enhanced patch cords according to the present invention may be integrated into a number of connections, as shown by FIG. **2**, in which a horizontal cable plant **28** having multiple cables is enhanced by enhanced patch cords **30** and **32** provided at first and second ends of the communication path.

The enhancement of signal-to-noise ratio using enhanced patch cords according to the present invention is shown in FIG. **3**. The dotted line shows the reduced signal and noise resulting from the enhanced patch cords across the communication frequencies. Because the noise due to alien crosstalk is attenuated to a greater degree than the signal, both the available bandwidth and the signal-to-noise ratio are improved in systems employing enhanced patch cords according to the present invention.

Attenuation may be introduced into patch cords and other communication cabling using a variety of methods. There are two design parameters to consider in the design of a lossy patch cord. One parameter is the amount of insertion loss to include in the cable, and the second is the amount of alien crosstalk suppression or susceptibility to have in the cable. Both parameters are preferably addressed in a cable design.

Dielectric loss may be increased as shown in FIG. **4** by providing a conductor **34** within lossy conductor insulation **36** or **38**. Dielectric loss can also be increased by using such methods as: (a) cable jacket dielectric lossy material; (b) cable spline dielectric lossy material; and (c) a wire pair shield (which concentrates the E&M field through the wire insulation).

The use of a less conductive wire (for example, aluminum wire instead of copper wire) will also increase conductor loss. As mentioned above, conductor loss can also be increased by decreasing the conductor wire diameter or increasing the twist per unit length. Increasing the amount of twisting increases the effective length of the cord and hence increases the conductor loss.

Conductor loss can also be increased by "tinning" a metal wire. A less-conductive coating on the circumference of the wire will increase the conductor loss because the current density congregates near the surface (via the skin effect) and will experience a higher loss through the tinned material. The use of stranded wire can also increase conductor loss, with an increase of loss by roughly 20% for comparable wire gauges. FIG. **5** shows a cross-sectional view of a cable **40** employing tinning and stranded wire. In the embodiment of FIG. **5**, stranded copper conductors **42** are provided within a tin skin **44**. FIG. **6** is a detail view of the detail "A" of FIG. **5**. The skin is provided at a depth d_s.

The use of wire with a roughened surface can also increase the conductor loss through the wire.

FIGS. **7***a* and **7***b* illustrate a technique to decrease the susceptibility of a cable by increasing the physical distance between crosstalk pairs. First and second cables **46** and **48** are placed in an abutting relationship. When the cable jacket material **50** is increased in thickness—for example, to jacket **52**, as shown in FIG. **7***b*—the distance between crosstalk pairs is increased from d_1 shown in FIG. **7***a* to d_2 shown in FIG. **7***b*. According to one embodiment, the cable jacket material **50** is a foamed jacket material. Cable separators may also be used to increase separation between neighboring cables.

Metallic shielding can also be used to reduce susceptibility of alien signals into a signal cable pair. FIG. **8** is a cross-sectional view showing a technique to decrease the susceptibility of a cable by the incorporation of a conductive shield. In FIG. **8**, conductive pairs **52** are provided within an overall conductive shield **54**. The conductive shield **54**, in turn, is provided within a jacket **56**. As shown in FIG. **9** (which incorporates a detail view), in another embodiment a layer of overall shielding **54** may be provided between first and second layers **58** and **60** of jacketing material.

FIG. **10** shows another embodiment, in which individual shielding **62** surrounds each wire pair.

Another embodiment is shown in FIG. **11**, which illustrates the use of a conductive spline **64** or conductive pair separator used to decrease susceptibility.

In another embodiment, crosstalk may be reduced by modifying the lay of a cable along its length. The lay of a cable refers to the twisting of a cable along its length. In this embodiment, fixed twisted pair lengths are provided along the length of a cable. Four or more cable lay values providing a four-pair cable with twisted pair lengths over the length of the cable meeting the proposed 10 Gb/s Ethernet Near-End Crosstalk (NEXT) requirement are selected. Any four or more cable lay values are chosen at random, with the selection process being described as follows:

1. Cable lays (A, B, C, D, . . .) are selected, with each of the lays meeting the 10 Gb/s Ethernet NEXT requirement.
2. Any of the four cable lays are selected without replacement during the cable lay process.
3. The selected cable lay is provided over a uniform or random length of cable less than or equal to ten meters.
4. Any of the three or more remaining cable lays are selected and applied to the cable construction as described in step 3.
5. The process is repeated until all cable lays have been assigned.

A diagram of a cable length employing random distances between cable lay transitions and using four different cable lays is shown in FIG. **12**.

While particular embodiments and applications of the present invention have been illustrated and described, it is to be understood that the invention is not limited to the precise construction and compositions disclosed herein and that various modifications, changes, and variations may be apparent from the foregoing descriptions without departing from the spirit and scope of the invention as defined in the appended claims.

What is claimed is:

1. A network system comprising:

a first communication cable connected via a first enhanced patch cord to a first network device, the first enhanced patch cord being a first attenuating patch cord having a first patch cord attenuation greater than an attenuation of the first communication cable; and

a second communication cable connected via a second enhanced patch cord to a second network device, the second enhanced patch cord being a second attenuating patch cord having a second patch cord attenuation greater than an attenuation of the second communication cable,

wherein the first patch cord comprises a twisted-pair of a plurality of twisted communication wires having a greatest twists per length and the first communication cable also comprises a twisted-pair of a plurality of twisted communication wires having a greatest twists per length, the twisted-pair of the twisted communication wires of the first patch cord having the greatest twists per length having more twists per length than the twisted-pair of the twisted communication wires of the first communication cable having the greatest twists per length, and

wherein the attenuation of the first patch cord is greater due to the twisted-pair of the twisted communication wires of the first patch cord having the greatest twists per length having more twists per length than the twisted-pair of the twisted communication wires of the first communication cable having the greatest twists per length.

2. The network system of claim 1 wherein the attenuation of the first patch cord is greater than the attenuation of the first communication cable also due to at least one of the twisted communication wires of the first patch cord being at least two gauges narrower than at least one of the twisted communication wires of the first communication cable.

3. The system of claim 1 wherein the first patch cord is an unshielded patch cord.

4. A network system comprising:

a first communication cable connected via a first enhanced patch cord to a first network device, the first enhanced patch cord being a first attenuating patch cord having a first patch cord attenuation greater than an attenuation of the first communication cable; and

a second communication cable connected via a second enhanced patch cord to a second network device, the second enhanced patch cord being a second attenuating patch cord having a second patch cord attenuation greater than an attenuation of the second communication cable,

wherein the first patch cord comprises a plurality of twisted communication wires and the first communication cable also comprises a plurality of twisted communication wires, at least one of the twisted communication wires of the first patch cord having a narrower gauge than at least one of the twisted communication wires of the first communication cable, and

wherein the attenuation of the first patch cord is greater due to at least one of the twisted communication wires of the first patch cord being at least two gauges narrower than at least one of the twisted communication wires of the first communication cable.

5. The system of claim 4 wherein the first patch cord is an unshielded patch cord.

6. A patch cord for insertion in a communication path between a network device and horizontal communication cabling, the patch cord comprising: a patch cord attenuation greater than an attenuation of the horizontal communication cabling, the patch cord having a plurality of twisted communication wires, the horizontal communication cabling having a plurality of twisted communication wires, the twisted communication wires of the patch cord being at least two gauges narrower than the twisted communication wires of the horizontal communication cabling, and wherein the attenuation of the patch cord is greater due to the patch cord having a narrower gauge than the horizontal communication cabling.

7. The patch cord of claim 6 wherein a twisted-pair of the twisted communication wires of the patch cord having a greatest twists per length also has more twists per length than a twisted-pair of the twisted communication wires of the horizontal cabling having a greatest twists per length, wherein the attenuation of the patch cord is also greater than the attenuation of the horizontal cabling due to the twisted-pair of the communication wires of the patch cord having the greatest twists per length having more twists per length than the twisted pair of the communication wires of the horizontal cabling having the greatest twists per length.

8. The patch cord of claim 6 wherein the patch cord is an unshielded patch cord.

9. The patch cord of claim 6 wherein a twisted-pair of the twisted communication wires of the patch cord having a smallest twists per length also has more twists per length then a twisted-pair of the twisted communication wires of the horizontal cabling having a smallest twists per length, wherein the attenuation of the patch cord is also greater than the attenuation of the horizontal cabling due to the twisted-pair of the communication wires of the patch cord having the smallest twists per length having more twists per length than the twisted pair of the communication wires of the horizontal cabling having the smallest twists per length.

10. A network system comprising:

a first communication cable connected via a first enhanced patch cord to a first network device, the first enhanced patch cord being a first attenuating patch cord having a first patch cord attenuation greater than an attenuation of the first communication cable; and

a second communication cable connected via a second enhanced patch cord to a second network device, the second enhanced patch cord being a second attenuating patch cord having a second patch cord attenuation greater than an attenuation of the second communication cable,

wherein the first patch cord comprises a twisted-pair of a plurality of twisted communication wires having a smallest twists per length and the first communication cable also comprises a twisted-pair of a plurality of twisted communication wires having a smallest twists per length, the twisted-pair of the twisted communication wires of the first patch cord having the smallest twists per length having more twists per length than the twisted-pair of the twisted communication wires of the first communication cable having the smallest twists per length, and wherein the attenuation of the first patch cord is greater due to the twisted-pair of the twisted communication wires of the first patch cord having the smallest twists per length having more twists per length than the twisted-pair of the twisted communication wires of the first communication cable having the smallest twists per length.

11. The network system of claim **10** wherein the attenuation of the first patch cord is greater than the attenuation of the first communication cable also due to at least one of the twisted communication wires of the first patch cord being at least two gauges narrower than at least one of the twisted communication wires of the first communication cable.

12. The system of claim **10** wherein the first patch cord is an unshielded patch cord.

13. A patch cord for insertion in a communication path between a network device and horizontal communication cabling, the patch cord comprising: a patch cord attenuation greater than an attenuation of the horizontal communication cabling, the patch cord having a plurality of twisted communication wires, the horizontal communication cabling having a plurality of twisted communication wires, wherein a twisted-pair of the twisted communication wires of the patch cord having a smallest twists per length has more twists per length than a twisted-pair of the twisted communication wires of the horizontal cabling having a smallest twists per length, wherein the attenuation of the patch cord is also greater than the attenuation of the horizontal cabling due to the twisted-pair of the communication wires of the patch cord having the smallest twists per length having more twists per length than the twisted pair of the communication wires of the horizontal cabling having the smallest twists per length.

14. The patch cord of claim **13** wherein the patch cord is an unshielded patch cord.

15. A patch cord for insertion in a communication path between a network device and horizontal communication cabling, the patch cord comprising: a patch cord attenuation greater than an attenuation of the horizontal communication cabling, the patch cord having a plurality of twisted communication wires, the horizontal communication cabling having a plurality of twisted communication wires, wherein a twisted-pair of the twisted communication wires of the patch cord having a greatest twists per length has more twists per length than a twisted-pair of the twisted communication wires of the horizontal cabling having a greatest twists per length, wherein the attenuation of the patch cord is also greater than the attenuation of the horizontal cabling due to the twisted-pair of the communication wires of the patch cord having the greatest twists per length having more twists per length than the twisted pair of the communication wires of the horizontal cabling having the greatest twists per length.

16. The patch cord of claim **15** wherein the patch cord is an unshielded patch cord.

* * * * *